REMARKS

Claims 1-56 are pending in the application. In view of the following remarks, Applicant traverses the Office's rejections and respectfully requests that the application be forwarded on to issuance.

Allowable Subject Matter

Claims 24-26, 31-33, and 40 have been objected to as dependent upon a rejected base claim, but have otherwise been indicated as allowable.

Claims 43-49 have been allowed.

Applicant respectfully thanks that Examiner for the indication of allowable subject matter.

The Claim Rejections

Claims 1-9, 12-14, 16-20, 27-30, 35, 37, 50-54 and 56 stand rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 6,226,005 to Laferriere.

Claims 10, 11, 15, 36, 38-39 and 55 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Laferriere in view of U.S. Patent No. 6,111,582 to Jenkins.

Applicant's Disclosure

Before addressing the substance of the Office's rejections, the following description and explanation of Applicant's disclosure is provided in an attempt to illustrate ways in which the subject matter in Applicant's disclosure differs from the subject matter of the cited references.

Consider first the problem that Applicant's disclosure addresses. Specifically, Applicant's disclosure is directed to a more optimal approach in the field of ray intersection in which a ray is cast toward object. A majority of the processing that takes place in connection with ray intersection concerns searching for an object that is intersected by a cast ray. Typically, surfaces of objects are approximated by a plurality of shapes such as triangles and other polygons. Conventional searching techniques typically determine whether or not each and every shape that constitutes the approximated surface of an object is intercepted by the cast ray. For example, if the surface of an object is approximated by 6500 triangles, conventional searching algorithms test a first triangle to determine whether the cast ray intercepts it. If the first triangle is not intercepted by the cast ray, then the next triangle is tested and so on. Needless to say, processing each of the shapes used to approximate the surface of an object, while effective, is not the most optimal approach to the problem.

Applicant's disclosure describes approaches in which the total number of shapes that are typically evaluated by the conventional algorithms for an intersection is significantly reduced prior to evaluation. This reduction of the number of shapes to be evaluated is achieved by pre-characterizing aspects of the individual shapes that make up an object. Through pre-characterization processing, a sub-set of possible intersected shapes, which has a smaller number of shapes than the total number of shapes that approximate the surface of the object, is defined, with such sub-set being subsequently evaluated to ascertain those shapes within the sub-set that are intersected by the defined ray. Reducing the number of shapes that are evaluated for ray intersections greatly reduces the processing overhead thereby improving processing times. Improvements over

conventional processing techniques have been observed on the order of 5- to 10-times faster.

As a specific example that illustrates one of Applicant's embodiments in action, consider Applicant's Figs. 7-10.

Fig. 7 shows a collection of shapes 400 that comprise a triangle mesh approximating an object of interest. In this particular example, the collection constitutes 60 surfaces (each triangle comprising one surface) and 42 vertices. In the past, intersection algorithms have evaluated ***each*** of the separate triangles of the illustrated collection to determine whether there is an intersection with a cast ray. So, in this case, conventional methods might have started with the first triangle in the first column, evaluated it for an intersection, and then discarded it when there was no intersection. This method would then step through each of the triangles, similarly evaluating them for an intersection with the ray. With complex surfaces having a high degree of resolution (i.e. many shapes), processing overhead can be quite large. Advantageously, the described embodiment reduces the number of shapes that must be tested for an intersection. This saves greatly on processing overhead and increases the speed with which objects are processed.

Fig. 7 shows a ray that has been cast toward the object that is approximated by collection 400. The ray extends into and out of the plane of the page upon which Fig. 7 appears.

Fig. 8 shows a plane containing the ray that is perpendicular to the page upon which Figures 7 and 8 appear.

Fig. 9 shows a sub-set of shapes (shaded for clarity) that might be intersected by the ray. Here, an evaluation has been performed to determine whether the triangle(s) that are defined by the individual vertices straddle the

defined plane. If they do straddle the defined plane, then it is *possible* that they are intersected by the ray. Here, the number of triangles that have to be evaluated by an intersection algorithm have been reduced from 60 to 10.

Fig. 10 shows collection 400 after the intersection algorithm has been run on all of the triangles in the shaded sub-set of Fig. 9. In this example, only one triangle (shaded for clarity) is intersected by the ray.

The Laferriere Reference

Laferriere is directed to methods and systems that produce an illumination map for an object in a scene that is to be rendered. The object is textured mapped and is represented as a mesh of polygons.

According to Laferriere, its system provides for the calculation of an illumination map, either by determining the contributions of each light source in a scene or by performing a complete evaluation of all of the active components of a shade tree defined for the scene. When the specifics of Laferriere are explored in more detail, it is evident that what Laferriere discloses and teaches is very different from the embodiments that are claimed in the present application. As an example, consider the following.

As noted by Laferriere, in general, the production of an illumination map requires the determination of the points of interest within the scene and the determination of an illumination value within the scene at these points of interest. For non-texture mapped objects, the points of interest correspond to the vertices of the polygons in the mesh representing the object. For texture mapped surfaces, the determination of the points of interest is more complex and is discussed below.

In accordance with Laferriere's described embodiment, the user first selects one or more texture maps for which it is desired to determine illumination values. In Laferriere's SoftImage.vertline.3D, this selection can be accomplished by selecting one or more texture nodes in the schematic view of the scene definition. Next, the object or objects to which the texture picture is to be mapped are converted to polygon mesh representations, if they are not already represented as such, using a suitable tessellation algorithm.

In the above-mentioned SoftImage 3.vertline.D system and other systems, texture mapping can be performed by projection or by uv mapping (i.e--in uv space). If projected, either planar, cylindrical or spherical projections can be employed. Laferriere refers to a discussion of such projection techniques as taking place in a reference entitled "Advanced Animation and Rendering Techniques, Theory and Practice" by Watt & Watt. If uv mapping is employed, the texture picture is represented in, or converted to, uv coordinate space, wherein `u` represents the horizontal axis of the texture picture and ranges from 0.0 to 1.0 and `v` represents the vertical axis and also ranges from 0 to 1.0. The coordinates of the polygon(s) which are to be uv texture mapped are converted from xyz space to uv space, if they are not already expressed in uv coordinates, and the mapping is then performed.

For a better understanding of Laferriere's process, please refer Laferriere's Fig. 1 which shows a schematic representation of a texture picture 40 with a resolution of three pixels by three pixels. Fig. 2 shows a schematic representation of a 3D object 60, in this case a polygon mesh comprising four polygons.

Fig. 3 shows the result of converting polygon 60 to a tessellated representation 80 in uv space wherein the object is represented by eight triangular

polygons, 84 through 112, and the coordinates of the vertices of each triangle are shown in uv space.

Fig. 4 shows the result of the projection of texture picture 40 onto tessellated representation 80 of 3D object 60. As an example, the vertices of polygon 108 are at (0.0, 0.5), (0.5, 0.0) and (0.5, 0.5). In this example texture picture 40 was mapped entirely to object 60.

Next, the area occupied by each pixel of the texture on object 60 is determined in uv space from du=1.0/width and dv=1.0/height, where width is the horizontal resolution of the cropped area of texture picture 40 (in pixels) and height is the vertical resolution of the cropped area of texture picture 40 (in pixels) and the area occupied by a polygon pixel is therefore (du * dv).

The next step is to gather data for the points of interest on the object, a point of interest occurring for each intersection between a polygon on the object and a pixel in the cropped area of texture picture 40, referred to by Laferriere as a texel.

Each point of interest has a weight associated with it, the weight corresponding to the size of the area of intersection relative to the total area of the texel. There are several possible categories of intersection between a polygon and a texel, as shown in Laferriere's Figs. 5a through 5h, wherein the area of intersection is represented by a hatched polygon.

Fig. 5a shows the trivial case of no intersection area between polygon 120 and the area of texel 124 and thus polygon 120 would have a zero weight for texel 124 and no information would be stored for this texel. Fig. 5b shows the other trivial case of a complete intersection between polygon 120 and the area of texel 124 resulting in a weighting of 100%.

Figs. 5c, 5d and 5e show examples of a single vertex of polygon 120 falling within the area of texel 124. In such cases, the polygon representing the area of intersection can have three, four or five vertices, as shown respectively in these Figures. To determine the weight for a polygon 120, the area of the intersection is determined by any suitable means.

The vertices of the area of intersection (which is the hatched polygon in the Figures) are then determined.

Figs. 5f and 5g show examples wherein two vertices of polygon 120 fall within texel 124, resulting in the shape of the intersection area having four or five vertices, as shown respectively, and the areas of these intersection polygons are then determined.

Fig. 5h shows an example of the case wherein all three vertices of polygon 120 fall within texel 124 resulting in the intersection area corresponding to the shape (and area) of polygon 120.

Figs. 5i and 5j show examples wherein no vertices but one edge of polygon 120 intersects texel 124, resulting in the shape of the intersection area having three and four vertices respectively. Figs. 5k and 5l show examples wherein no vertices but two edges of polygon 120 intersect texel 124, resulting in the shape of the intersection area having five and six vertices respectively.

Finally, Fig. 5m shows an example wherein no vertices but three edges of polygon 120 intersect texel 124, resulting in the shape of the intersection area having six vertices.

A data structure, shown at 140 in Fig. 6, is then created for each texel in the cropped region of texture picture 40, which can comprise the entire texture picture 40 or any rectangular sub-region thereof. Data structures 140 store information

relevant to each texel, including information relating to the points of interest for the texel. Specifically, each data structure 140 stores a Diffuse color value 144 determined for the texel in normalized RGB color space (i.e.--R between 0.0 and 1.0, B between 0.0 and 1.0 and G between 0.0 and 1.0), an Ambient color value 148 determined for the texel in normalized RGB color space, the number 152 of points of interest for the texel and a pointer 156 to a linked list 160 of data structures 164 storing information for each of those points of interest.

To produce an illumination map, the process of Figs. 7a and 7b, is modified as follows. In step 232 the product of the light color and the weight 176 is accumulated (summed) to the illumination value for the texel. When, at step 240, it is determined that no additional points of interest remain to be considered for the texel, the process proceeds to step 216, rather than to steps 248 and 250. Steps 248 and 250, which deal with the ambient and diffuse contributions, are not required and can be omitted in this embodiment. When at step 216 there are no more texels to consider, the process completes at step 252 by storing the resulting illumination values to obtain the illumination map.

To employ an illumination map when rendering a scene, the illumination values in the illumination map are combined with the texel color of the texels in texture picture map 40, and, optionally, with an ambient color to obtain the rendered color.

Once an illumination map has been determined for a scene, textures can be changed and/or substituted as desired. For example, a scene can be rendered with walls to which a wood grain texture is been mapped. The scene can then be re-rendered, as a different setting in a game for example, with a marble texture mapped to the walls. In each case the same illumination map is employed in the

rendering process and thus, once an illumination map has been determined for a scene, the rendering time to render that scene is reduced.

The Office's Arguments

Claim 1 recites a method for determining which shapes are intersected by a ray in a computer graphic processing system in which a ray is cast toward an object represented by a collection of pre-determined shapes each characterized by characteristic data. Accordingly, the method recites:

- defining a reference object relative to the represented object;
- determining the positions of the shapes relative to the reference object using the characteristic data; and
- determining, on the basis of the positions of the shapes relative to the reference object, those shapes that have no chance of intersecting the ray, and those remaining shapes that may intersect the ray.

In making out the rejection of this claim, the Office argues that Laferriere discloses the act of "defining a reference object relative to the represented object" and cites to column 3, lines 13-16 in support thereof. Applicant respectfully disagrees. The cited passage states as follows:

> *determining the location of, area of and weight of the intersection between each pixel in said texture map and each polygon in said polygon mesh, the weight corresponding to the proportion of said area of intersection relative to the total area of said pixel;*

The context of this processing step in Laferriere is described above. What Laferriere is referring to here is very different from the recited act of "defining a reference object relative to the represented object" as that phrase is understood in

the context of Applicant's specification. Accordingly, for at least this reason, this claim is allowable.

In making out the rejection of this claim, the Office further argues that the act of "determining the positions of the shapes relative to the reference object using the characteristic data" is disclosed by Laferriere in column 3, lines 18-21. Applicant respectfully disagrees. The text of this cited passage appears directly below:

> *for each determined area of intersection, determining the product of illumination information at said determined location of intersection and the weight of said area of intersection;*

This text does not disclose or suggest Applicant's recited act of "determining the positions of the shapes relative to the reference object using the characteristic data", as that phrase is understood in the context of Applicant's disclosure. Accordingly, for at least this additional reason, this claim is allowable.

In making out the rejection of this claim, the Office further argues that the recited act of "determining, on the basis of the positions of the shapes relative to the reference object, those shapes that have no chance of intersecting the ray, and those remaining shapes that may intersect the ray" is disclosed by Laferriere in Figs. 5a-5m. Applicant respectfully but strongly disagrees.

As noted above in the section that specifically discusses Laferriere, each point of interest has a weight associated with it, the weight corresponding to the size of the area of intersection relative to the total area of the texel. There are several possible categories of intersection between a polygon and a texel, as shown in Laferriere's Figs. 5a through 5h, wherein the area of intersection is

represented by a hatched polygon. This subject matter in Laferriere and the related discussion in its specification in no way discloses or suggests a methodical act comprising "determining, on the basis of the positions of the shapes relative to the reference object, those shapes that have no chance of intersecting the ray, and those remaining shapes that may intersect the ray". Accordingly, for at least this additional reason, this claim is allowable.

When the subject matter of this claim is considered in its entirety in the context of Laferriere, it is overwhelmingly clear that Laferriere neither discloses nor suggests the subject matter of claim 1. Accordingly, for all of the reasons noted above, this claim is allowable.

Claims 2-15 depend from claim 1 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 1, are neither disclosed nor suggested in the references of record, either singly or in combination with one another. In addition, given the allowability of these claims, Jenkins is not seen to add anything of significance to the rejection of claims 10, 11, and 15.

Claim 16 recites a method for determining which of a collection of pre-determined shapes are intersected by a ray cast toward an object that is represented by the shapes. The method recites:

- defining a collection of polygons that approximate an object, individual polygons having a plurality of vertices;
- casting a ray toward the approximated object;
- defining a reference object relative to the collection of polygons and that contains the cast ray;
- pre-characterizing at least some vertices of at least some of the polygons to provide characteristic data that describes the vertices' positions relative to the reference object; and

- using the characteristic data to ascertain the positions of the individual polygons relative to the reference object.

In making out the rejection of this claim, the Office argues that Laferriere discloses the subject matter of this claim and cites the following passages in support thereof: column 1, line 66 through column 2, line 8; column 2, lines 18-20; column 3, lines 18-21, and column 9, lines 6-13. Applicant respectfully disagrees that Laferriere anticipates the subject matter of this claim.

First, it is not apparent that Laferriere's process pertains at all to one that determines ***which of a number of shapes are intersected by a ray***. Sure, Laferriere does disclose that objects can be rendered using ray tracing (see column 2, lines 18-20). Ray tracing in and of itself is not new. What is new is the subject matter recited in Applicant's claim which is used ***in conjunction with a system in which a ray is cast toward an object.***

The specific passages cited by the Office do not anticipate the subject matter of this claim. For example, nowhere does Laferriere disclose or suggest:

- defining a reference object relative to the collection of polygons and that contains the cast ray;
- pre-characterizing at least some vertices of at least some of the polygons to provide characteristic data that describes the vertices' positions relative to the reference object; and
- using the characteristic data to ascertain the positions of the individual polygons relative to the reference object.

It appears that the Office is arguing that Laferriere's processing in which a weight for a polygon is determined by determining the area of intersection with a texel anticipates the subject matter of this claim. Laferriere does not define a ***reference object*** as that term is used in Applicant's specification. Further,

Laferriere does not pre-characterize at least some vertices of at least some of the polygons to provide characteristic data that describes the vertices' positions relative to the reference object, and then use the characteristic data to ascertain the ***positions of the individual polygons*** relative to the reference object, with the outcome of the processing being a determination as to which of the polygons is intersected by a cast ray.

Accordingly, for all of these reasons, this claim is allowable.

Claims 17-23 depend from claim 16 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 16, are neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Claim 27 recites a method for determining which of a number of shapes that represent an object are intersected by a ray that is cast toward the object. The method recites:

- defining a plurality of triangles that approximate an object, individual triangles having three vertices;
- casting a ray toward the approximated object;
- defining at least one plane relative to the approximated object to contain the ray;
- pre-characterizing the vertices of the plurality of triangles to provide characteristic data that describes the positions of the vertices relative to said at least one plane; and
- using the characteristic data to ascertain the positions of the individual triangles relative to said at least one plane.

In making out the rejection of this claim, the Office sets out a number of general teachings in Laferriere but does not appear to apply those teachings to the

subject matter of Applicant's claim. Applicant has thoroughly reviewed Laferriere, particularly those sections that have been cited by the Office, and can find no disclosure or suggestion of the subject matter of the present claim. For example, nowhere can Applicant find any disclosure or suggestion of a method that defines a plurality of triangles that approximate an object, individual triangles having three vertices; casts a ray toward the approximated object; ***defines at least one plane relative to the approximated object to contain the ray***; pre-characterizes the vertices of the plurality of triangles to provide characteristic data that describes the positions of the vertices relative to said at least one plane; and uses the characteristic data to ascertain the positions of the individual triangles relative to said at least one plane.

Accordingly, for at least this reason, this claim is allowable.

Claims 28-30 and 34-36 depend from claim 27 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 27, are neither disclosed nor suggested by the references of record, either singly or in combination with one another. Additionally, given the allowability of claim 36, the rejection over the combination of Laferriere and Jenkins is not seen to add anything of significance.

Claim 37 recites a method for determining which of a number of polygons that represent an object are intersected by a ray that is cast at the object. The method recites:

- defining a sub-set of polygons from a collection of polygons that approximate an object by determining which polygons have vertices

that satisfy a predefined relationship relative to a reference object; and

- evaluating the sub-set of polygons to ascertain which of the polygons is intersected by a cast ray.

In making out the rejection of this claim, the Office again notes several of the general teachings of Laferriere, but appears to fail to apply those teachings to the subject matter of Applicant's claim. Applicant has reviewed the subject matter of Laferriere and can find no disclosure, teaching, or suggestion of Applicant's claimed method. For example, Laferriere does not disclose or suggest defining a sub-set of polygons from a collection of polygons that approximate an object ***by determining which polygons have vertices that satisfy a predefined relationship relative to a reference object***; and ***evaluating the sub-set of polygons to ascertain which of the polygons is intersected by a cast ray***. The passages cited by the Office simply refer to (1) a tessellation process in which a polygon mesh is utilized to represent a 3-D object, (2) the rendering of objects represented by such meshes by performing a scan line or ray tracing process, (3) determining parameters associated with an intersection between pixels in a texture map and individual polygons in the polygon mesh, and (4) projecting a texture picture onto a tessellated representation of an object. This subject matter is different from and does not anticipate the subject matter of this claim. Accordingly, for at least this reason, this claim is allowable.

Claims 38, 39, 41 and 42 depend from claim 37 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 37, are

neither disclosed nor suggested by the references of record, either singly or in combination with one another.

Claim 50 recites a computer graphic processing system comprising:

- a processor;
- memory; and
- software code stored in the memory that causes the processor to implement a ray-intersection algorithm which:
  - casts a ray at a collection of shapes that approximate an object;
  - defines a reference object that contains the ray;
  - pre-characterizes aspects of individual ones of the shapes of the collection to provide characteristic data; and
  - uses the characteristic data to ascertain the position of the shapes of the collection of shapes relative to the reference object.

In making out the rejection of this claim, the Office again notes several of the general teachings of Laferriere, but appears to fail to apply those teachings to the subject matter of Applicant's claim. Applicant has reviewed the subject matter of Laferriere and can find no disclosure, teaching, or suggestion of Applicant's claimed subject matter. For example, Laferriere does not disclose or suggest a system that embodies software code that implements a ray-intersection algorithm that casts a ray at a collection of shapes that approximate an object, ***defines a reference object that contains the ray***, pre-characterizes aspects of individual ones of the shapes of the collection to provide characteristic data, uses the characteristic data ***to ascertain the position of the shapes of the collection of shapes*** relative to the reference object.

Accordingly, for at least this reason, this claim is allowable.

Claims 51-56 depend from claim 50 and are allowable as depending from an allowable base claim. These claims are also allowable for their own recited features which, in combination with those recited in claim 50, are neither disclosed nor suggested by the references of record, either singly or in combination with one another. In addition, given the allowability of these claims, the rejection of claim 55 over the combination with Jenkins is not seen to add anything of significance.

<u>§112 Rejections</u>

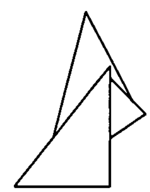
Claims 23 and 34 stand rejected under 35 U.S.C. §112, second paragraph. In making out this rejection, the Office states that "applicant has failed to illustrate or define how the above statement is applicable."

Claim 23 further modifies the subject matter of claim 16 from which it depends and recites "wherein non of said polygons share a vertex." Claim 34 further modifies the subject matter of claim 27 and recites "wherein none of the triangles share any vertices."

The specification, starting on page 10, lines 10 sets forth as follows:

> As shown in Fig. 3, there are four depicted triangles, 302, 304, 306, and 308 having the vertices V_1-V_7 as indicated. There can be many thousands of triangles used to approximate the surface of an object. Additionally, the collection of triangles can be arranged to have different topologies. Exemplary topologies are shown in Figs. 4-6. Specifically, Fig. 4 shows a topology known as a triangle mesh; Fig. 5 shows a topology known as a triangle strip; and Fig. 6 shows a topology known as a triangle fan. The collection of triangles can be arranged so that some of them share a side and/or vertices. *For example, in Fig. 3, triangles 302 and 304 share a vertex, while triangles 304 and 306 share a side and two vertices.* ***Other collections can be defined where none of the triangles share a vertex.*** Although triangles are depicted in the illustrated and described embodiment, it is to be understood that other shapes or polygons can be used to approximate an object.

Consider the collection of polygons below, where the polygons comprise, in this example, triangles:



In this particular example, none of the polygons share a vertex. Accordingly, Applicant has demonstrated one example of subject matter that falls within the context of these two claims. Accordingly, Applicant respectfully traverses the Office rejection.

Claims 41-42 stand rejected under §112, second paragraph. In making out the rejection of these claims, the Office states that the claims "recite the limitation 'computer graphic processing' in claim 37." The Office then contends that there is insufficient antecedent basis for this limitation. Applicant does not understand the Office's rejection. Claim 37 is a ***method*** claim. Claims 41 and 42 further claim the method of claim 37 embodied as computer-readable instructions on a computer-readable medium (claim 41) and as part of a programmable computer having memory that contains software code that implements the method of claim 37 (claim 42). Applicant can find nothing inappropriate about the recitations of these claims. Accordingly, these claims are in proper format and are allowable as indicated above.

Conclusion

All of the claims are in condition for allowance. Accordingly, Applicant requests a Notice of Allowability be issued forthwith. If the Office's next anticipated action is to be anything other than issuance of a Notice of Allowability, Applicant respectfully requests a telephone call for the purpose of scheduling an interview.

Respectfully Submitted,

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